Distribution, Abundance and Population Structuring of Beaked Whales in the Great Bahama Canyon, Northern Bahamas

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LONG-TERM GOALS

Atypical mass strandings of beaked whales have been correlated with naval sonar exercises (e.g. Simmonds and Lopez-Juraco 1991; Frantzis 1998; Evans and England 2001) highlighting a need for a better understanding of beaked whale population ecology. The long-term goal of this project is to fill key data gaps on the distribution, abundance, habitat use and population structuring of beaked whales in the Great Bahama Canyon. The study area includes the US Navy's Andros-AUTEC Operating Areas where fleet readiness training involves regular use of mid-frequency active sonars.

OBJECTIVES

The primary objectives of the three-year study are:

1) To use visual survey techniques to document beaked whale distribution and habitat use, and to estimate abundance in the Great Bahama Canyon (Figure 1).

2) To use photo-identification techniques to extend an existing photographic catalogue of individual beaked whales, which will be queried to examine the distribution, movements and social affiliations of identified individuals, and to assess abundance using mark-recapture techniques.

3) To use remote biopsy techniques to collect skin and blubber samples to contribute to the study of beaked whale diet (through fatty acid, stable isotope and contaminant analyses) and stock structure (using molecular genetic approaches).

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14. ABSTRACT
Atypical mass strandings of beaked whales have been correlated with naval sonar exercises (e.g. Simmonds and Lopez-Juraco 1991; Frantzis 1998; Evans and England 2001) highlighting a need for a better understanding of beaked whale population ecology. The long-term goal of this project is to fill key data gaps on the distribution, abundance, habitat use and population structuring of beaked whales in the Great Bahama Canyon. The study area includes the US Navy?s Andros-AUTEC Operating Areas where fleet readiness training involves regular use of mid-frequency active sonars.

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APPROACH

Using standardized line-transect methods, three ship-based visual and acoustic surveys were completed to assess patterns of distribution and relative abundance in the Great Bahama Canyon. Transect lines were randomly placed within four rectangular strata (NE Providence Channel, NW Providence Channel, Tongue of the Ocean and the Cul de Sac, Figure 1) using a saw-tooth pattern to allow equal area coverage. Upon sightings, the ship broke transect to confirm species identification, estimate group size and to collect photo-ID and biopsy samples. An additional fourth survey returned to areas of highest concentration of beaked whales to increase the number of biopsy samples.

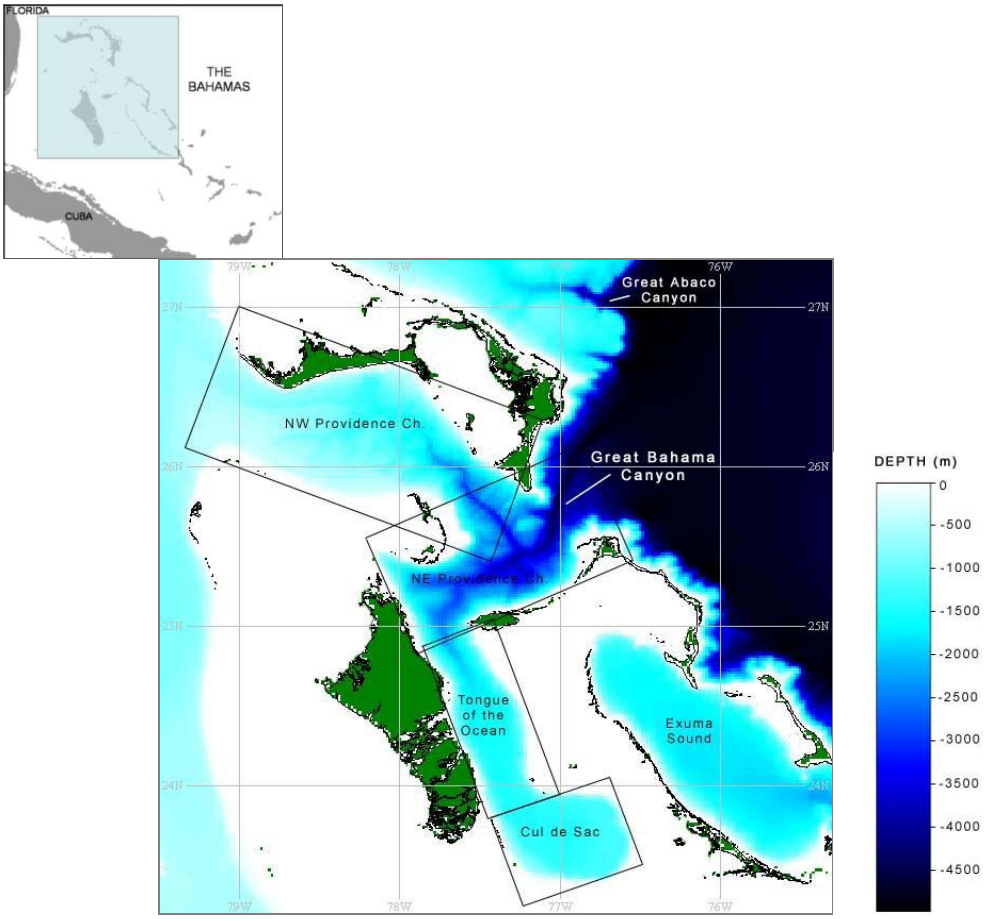

Figure 1. The Great Bahama Canyon branches into Northwest Providence Channel and from Northeast Providence Channel south into Tongue of the Ocean and the Cul de Sac. The canyon reaches depths of more than 4000m. The four survey grids are shown.

WORK COMPLETED

Ship-based surveys covered 8,885 km of visual search effort; including searches during 85 random transect lines. There were 127 sightings of beaked whales in the Great Bahama Canyon, comprising 3 species: Blainville's beaked whale (Mesoplodon densirostris), n=64, Gervais' beaked whale (M. europaeus), n=10 and Cuvier's beaked whale (Ziphius cavirostris), n=31 (Figure 2). Seventy-seven sightings were made during line transects which can be used to model detection probabilities for

analysis of abundance and density using Multiple Covariates Distance Sampling and Density Surface Modeling methods (to begin during FY10).

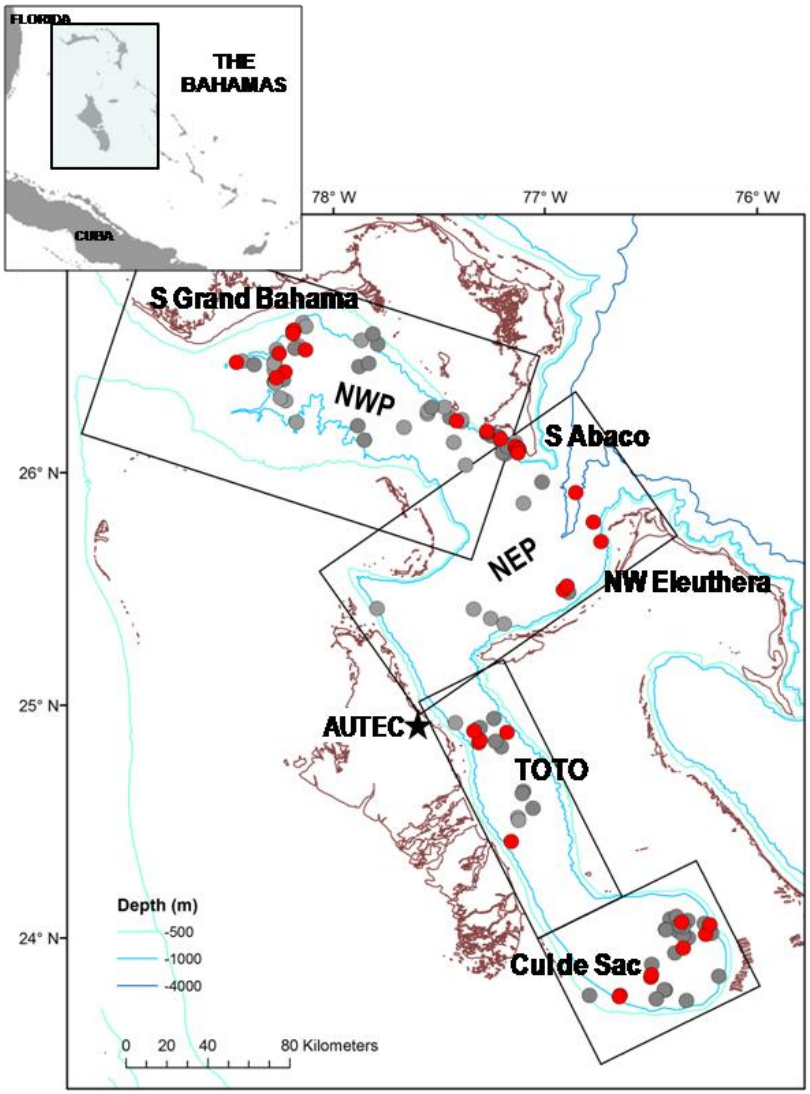

Figure 2. Beaked whale sightings in the Great Bahama Canyon during which biopsy samples were taken (red circles) and were not taken (grey circles). The four rectangular survey grids in NW Providence (NWP) and NE Providence Channels, Tongue of the Ocean (TOTO) and the Cul de Sac are shown.

Analysis to identify primary foraging habitats and prey preferences has been completed under the direction of G. Ylitalo at NOAA's Northwest Fisheries Science Center. Blubber and skin biopsy samples from 48 individual beaked whales were analyzed for their nitrogen and carbon stable isotope ratios, blubber fatty acids, and lipid class compositions. Blubber samples will also be analyzed for persistent organic pollutants (POPs) which will be completed in FY10. Genetic analysis of population structure and relatedness will be conducted by P. Morin at NOAA's Southwest Fisheries Science Center in FY10, involving DNA extraction, sequencing and genotyping of 91 archival and recent beaked whale samples.

RESULTS

Nitrogen and carbon stable isotope ratios and blubber fatty acids were analyzed in biopsy samples from 48 beaked whales (Blainville's, n=28; Cuvier's, n=19; Gervais', n=1). The patterns of dietary fatty acids are notably different among the three species (Figure 3), suggesting that they feed on largely different prey.

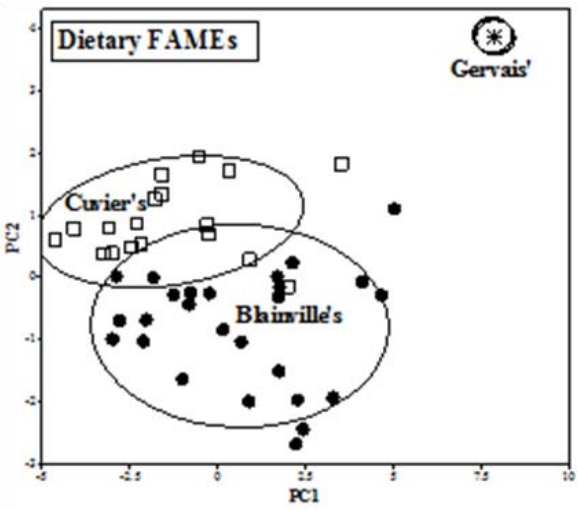

Figure 3. Principal Component Analysis plot depicting the differences in dietary fatty acid profiles among Blainville's (closed symbols), Cuvier's (open symbols), and Gervais' (asterisk) beaked whales. Ovals represent the 80% probability density intervals for each species.

Stable isotopes ratios also differed among species, with higher 15N isotope values and lower 13C isotope values found in Blainville's than in Cuvier's beaked whales ($p<0.05$), suggesting that Cuvier's whales not only feed upon prey that is different from the Blainville's whales, but also feed in different habitat, possibly greater depths. Differences in isotope ratios were also found among foraging regions suggesting that whales feed repeatedly within localized areas rather than foraging throughout the entire Great Bahama Canyon study area (Figure 4) [1]. Mark-recapture analysis of photo-identification data has also shown site-fidelity of Blainville's beaked whales to the AUTEC range in Tongue of the Ocean and to long-term study sites off Abaco, providing further support for population structuring on a relatively small spatial scale. The planned genetic analyses will help elucidate this hypothesis.

[1] Analysis reported by David P Herman, Douglas G. Burrows, Gladys K. Yanagida, Richard H. Boyer and Gina M. Ylitalo, NOAA Northwest Fisheries Science Center.

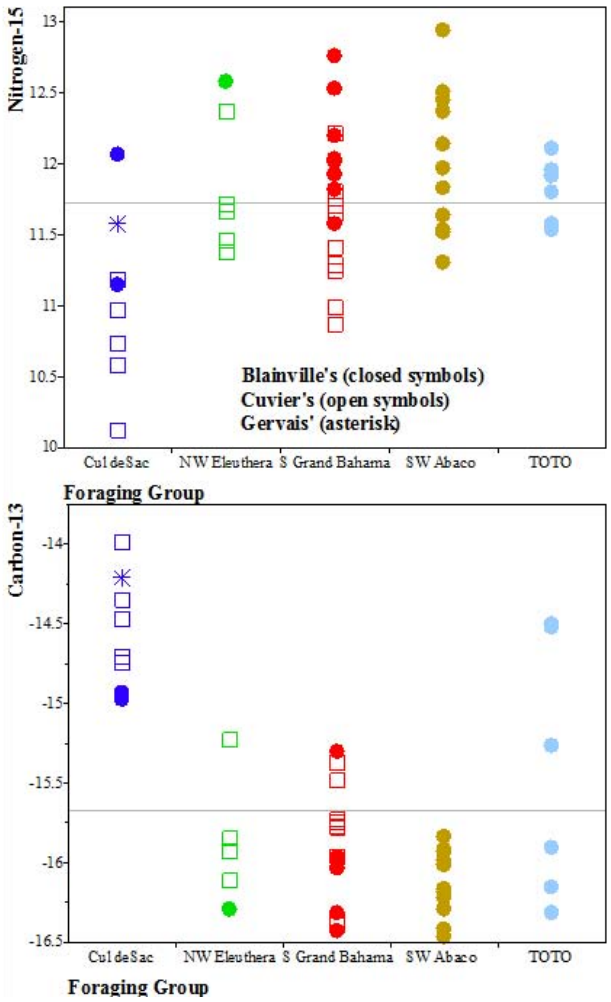

Figure 4. Comparison of stable isotope ratios (^{15}N and ^{13}C) among the five identified sampling/forgaing locations for Blainville's (closed symbols), Cuvier's (open symbols), and Gervais' (asterisk) beaked whales.

IMPACT/APPLICATIONS

This project has taken the first steps towards providing information on the baseline population ecology of beaked whales in these areas and adjacent waters to understand and mitigate the effects of naval activities. This multi-faceted study is providing key data on the population ecology of beaked whales on and around the US Navy ranges in the Bahamas, information which is critical to future mitigation and monitoring. For example, the relatively high density of beaked whales in the NW Providence Channel may explain why the highest mortality of beaked whales occurred along the southern coast of Grand Bahama Island during the anti-submarine warfare GAP exercise on 15th March 2000. However, these results are preliminary and should be interpreted as such.

RELATED PROJECTS

Behavior Response Study (BRS)
This is a large, multi-national project in which responses of whales exposed to underwater sounds are measured to identify and mitigate their adverse effects. Phase I of the study took place in Tongue of

the Ocean and was led by Dr. Ian Boyd (SMRU) as the Chief Scientist and holder of Bahamian research permit, and the Principal Investigator and holder of US permit was Dr. Brandon Southall (National Oceanographic and Atmospheric Administration (NOAA)). The project is supported by the Office of Naval Research (ONR) and US Department of Defense (NAVSEA PEO IWS Mr. Joseph Johnson and OPNAV N45 Dr. Frank Stone). Diane Claridge is a co-Principal Investigator. Photo-identification data and tissue samples collected during BRS will be contributed towards analysis of population structuring of beaked whales in the Great Bahama Canyon.

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